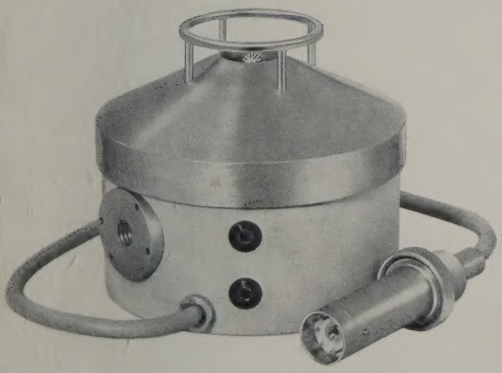
4219

Instructions and Applications



Artificial Voice Type 4219

A sound pressure regulated artificial voice applicable to general acoustic work and telephone test measurement in the frequency range 50 Hz to 10 kHz. The voice is equipped with a standard B & K condenser microphone and pre-amplifier, which when used with the compressor circuit of a B & K oscillator provides a means of sound pressure regulation to within ± 1 dB.

BRÜEL & KJÆR

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ARTIFICIAL VOICE TYPE 4219

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1. INTRODUCTION

The Artificial Voice Type 4219 is a complete redesign of the Artificial Mouth Type 4216. It is intended for use in laboratories and quality production control, when a well defined sound source is required, and when it is more convenient to use an artificial source rather than the human voice.

The Artificial Voice produces a sound field similar to the sound field from a human mouth, and also covers the frequency and pressure ranges normally produced by the human voice.

It is equipped with a built-in condenser microphone and preamplifier, which can be used with the compressor circuit of a B & K Beat Frequency Oscillator to maintain a constant sound pressure at the orifice.

The characteristics of the voice make it suitable for general acoustic work, and telephone measurements.

2. DESCRIPTION

2.1. GENERAL

The Artificial Voice consists of a small dynamic loudspeaker of 90 mm diameter, mounted in a rigid walled aluminium housing. The input impedance of the loudspeaker is 8 Ω..The power rating is 3 W.

The removable mouthpiece is located in front of the loudspeaker, and it has a circular opening of 20 mm diameter. A 1/4 inch Microphone Type 4136 is mounted at an angle below the mouthpiece, with the diaphragm in the centre of the orifice.

Fig.2.1. Photograph of Artificial Voice exterior (showing mounting plate and loudspeaker input sockets)

A lip ring is mounted on the mouthpiece and positioned 10 mm above the mouth opening. The outside diameter of the lip ring is 48 mm. The pressure drop with distance from the plane of the lip ring is similar to the pressure drop with distance from the lips of a human source. The lip ring

can be used as a reference plane when taking measurements at varying distances from the Voice. The lip ring can be removed to allow direct pressure measurement or to allow the mounting of special jigs. The lip ring is removed by unscrewing the mouthpiece and removing the four retaining screws on the inside of the mouthpiece. The screw holes may then be used to mount special jigs if required.

The positions of the orifice and lip ring have a definite position relative to the body of the Voice. This relative position is defined by the locating ridge below the mouthpiece, see Fig.2.1.

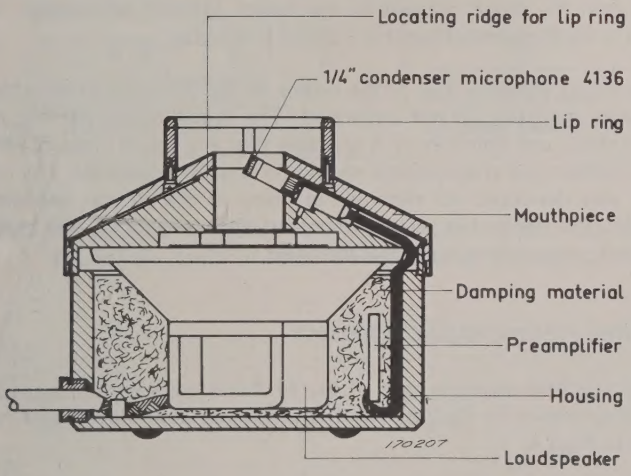

Fig.2.2. Sectional view of the Artificial Voice Type 4219

The microphone socket has a spring-loaded contatct, which is gold plated to ensure the best possible electrical connection and low contact noise level.

The Artificial Voice has its own built-in preamplifier and is supplied with 2 m (approx. 6'6") of cable terminated in a standard 7 pin plug, Type JP 0701. The attenuation of the preamplifier and cable, when used with the 1/4 inch Microphone 4136, is approximately 1 dB.

The input sockets to the loudspeaker are situated below the mouthpiece and to one side of the mounting plate. The sockets will accept standard banana plugs, B & K Type JP 0002.

The mounting plate is drilled, and tapped with 3/8 inch W thread and has four locating holes on its flat surface. These locating holes are intended for use with the B & K Electroacoustic Telephone Transmission Measuring System Type 3352. The preamplifier cable outlet, and the loudspeaker input sockets are positioned at the side of the mounting plate so as to enable easy access when the Voice is mounted on a test stand or test head.

The Artificial Voice may be used for measurements under closed volume measurements as well as for free field measurements. By employing the Microphone Type 4136, supplied with the Artificial Voice, and using an automatic regulation system, as on the Beat Frequency Oscillator Type 1022, then the sound pressure at the orifice can be kept constant within ± 1 dB in the frequency range from 50 Hz to 10 kHz.

The sound pressure level at the orifice of the Voice varies with frequency, when regulation is not employed. The regulating circuit has limited effectiveness, and therefore it is desirable that any sound pressure variation in the unregulated characteristic should be as small as possible. The internal design was developed to eliminate as many of the natural resonances as possible. The design has greatly improved the unregulated, and hence the regulated pressure/frequency characteristic.

2.2. FREE FIELD CHARACTERISTICS

The free field characteristics of the Artificial Voice were measured using the set-up shown in Fig.2.3. The frequency response curves obtained are shown in Fig.2.4.

The sound pressure level was measured in the mouth orifice by means of the built-in condenser microphone. In Fig.2.4 the two lower curves were obtained with different Sound Pressure Levels i.e. with different attenuation of the feedback voltage to the compressor circuit in the Beat Frequency Oscillator. The upper curve was obtained without any regulation.

The free field characteristics at different frequencies and distances along the axis from the Artificial Voice were measured using the set-up shown in Fig.2.5. The characteristics are for distances (d) from 0 to 20 cm measured from the lip ring of the Voice. The sound pressure level at the mouth opening was kept constant at 115 dB re 2×10^{-5} N/m^2 by using the built-in regulating Microphone Type 4136. For measurement two microphones were used. For distances below 5 cm a 1/4 inch Microphone Type 4135 was used,

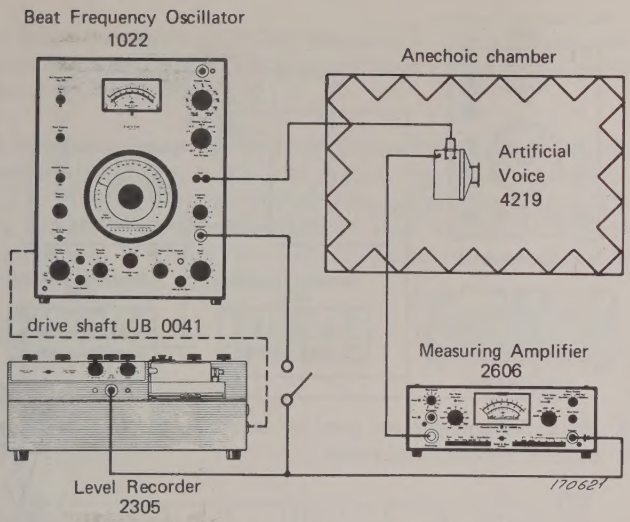

Fig.2.3. Measuring arrangement used for recording the free field characteristics of the Artificial Voice, measured at the orifice

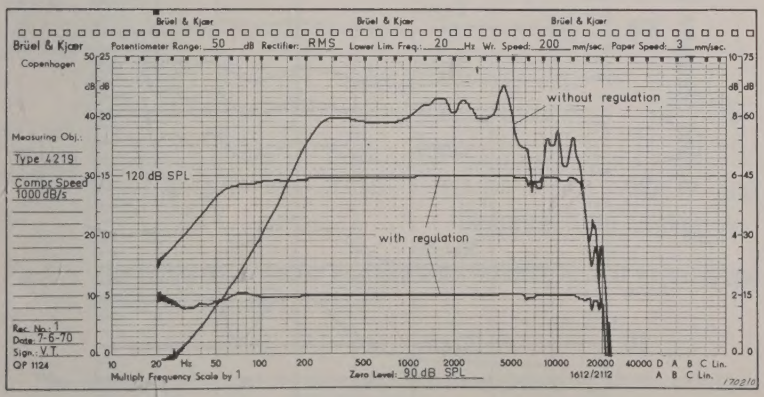

Fig.2.4. Frequency response curves obtained using arrangement shown in Fig.2.3.

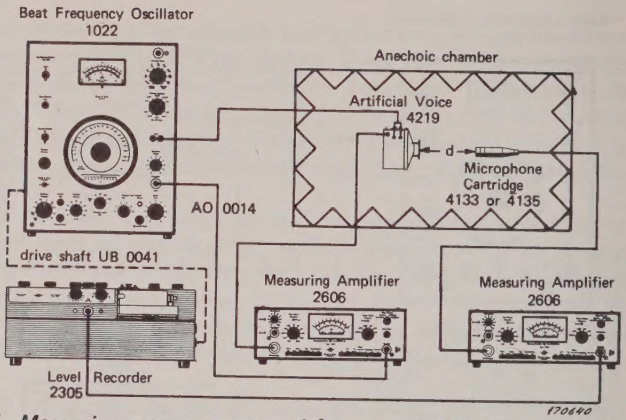

Fig.2.5. Measuring arrangement used for recording the free field characteristics of the Artificial Voice

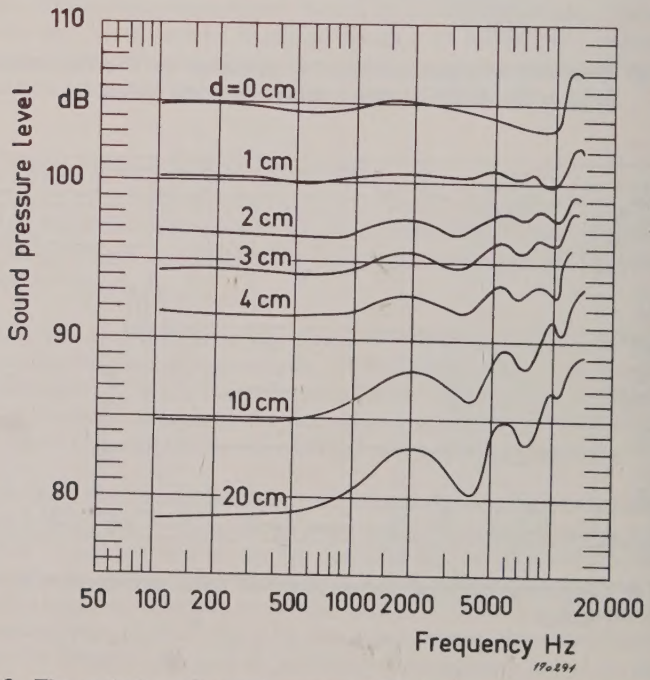

Fig.2.6. The variation of sound pressure with frequency and distance using the arrangement shown in Fig.2.5.

and for greater distances a 1/2 inch Microphone Type 4133 was used. Both microphones are of the free field type, and have a linear frequency response over the range of measurements.

The variation in sound pressure with distance at a discrete frequency was measured using the same set-up as in Fig.2.5. The result obtained is shown in Fig.2.7. The frequency was 200 Hz. The results in Fig.2.6 and 2.7 can be used to determine the sound pressure at other frequencies and distances. After a distance of 20 cm, the sound pressure falls approximately 6 dB every time the distance is doubled.

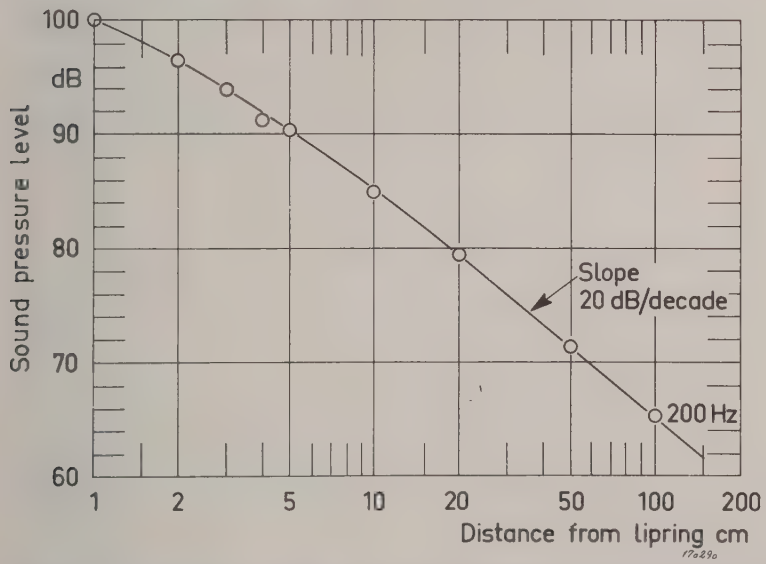

Fig.2.7. The variation of sound pressure with distance at 200 Hz using the arrangement shown in Fig.2.5.

The variation of sound pressure with distances very close to the mouth is shown in Fig.2.8. The measurement was made using a continuously swept signal, cycling from 200 Hz to 4 kHz to 200 Hz per second. The distance measured is relative to the plane of the lip ring. The pressure is referred to 0 dB at 4 cm from the lip ring. The measuring microphone was 1/4 inch Type 4135 free field microphone. The built-in microphone was used for the regulating circuit.

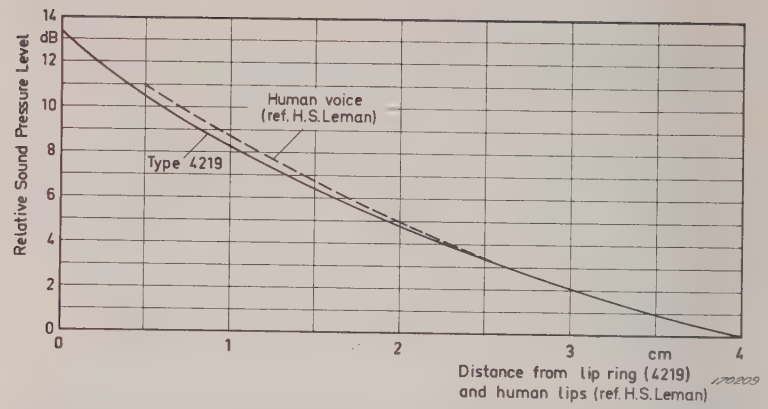

Fig.2.8. Sound field along the axis of the Voice near the orifice, compared with measurements for the human mouth by H.S. Leman

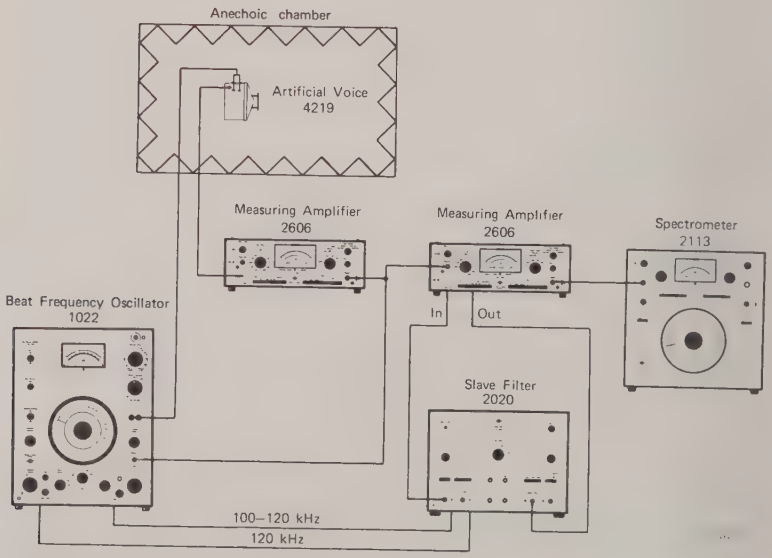

Fig.2.9. Measuring arrangement for recording the frequency characteristic and the harmonic components produced by the Artificial Voice Type 4219 for an open mouth

The comparison is made with measurements by H.S. Leman on human mouth using a test sentence, (Speech pressure near the human mouth, International Congress on Acoustics IV, Copenhagen 1962, paper B 36). The pressure variation of the Artificial Voice deviates less than 0.6 dB from that of the human mouth as measured by Leman.

The second and third harmonics of the sound pressure were measured using the arrangement shown in Fig.2.9. Measurements were taken at specific frequencies, and the characteristics obtained are shown in Fig.2.10. The harmonics are given relative to the level of the fundamental, which has a sound pressure level of 120 dB re 2×10^{-5} N/m^2. The sound pressure level at the orifice was kept constant by use of the regulating circuit.

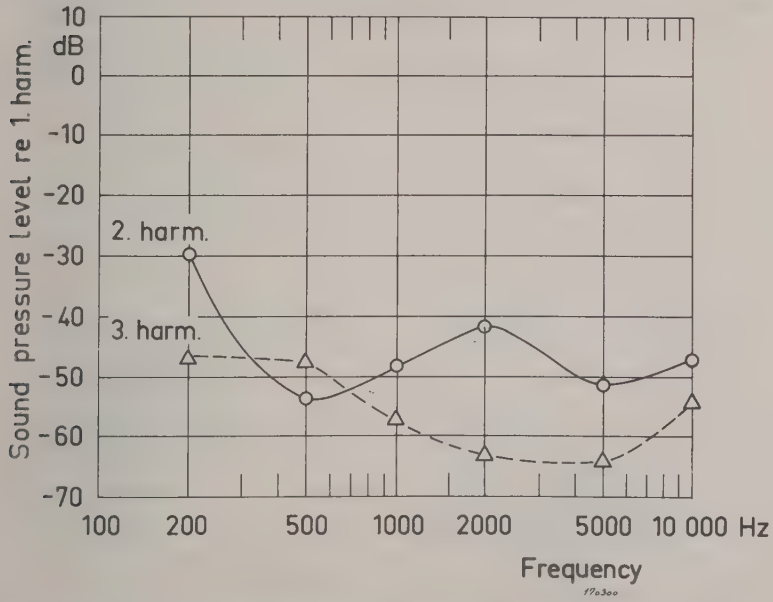

Fig.2.10. 2nd and 3rd harmonics of sound pressure, measured in the mouth orifice for an open mouth

2.3. CLOSED VOLUME CHARACTERISTICS

The closed volume characteristics were obtained by closing the mouth orifice with a steel disc and by using the set-up shown in Fig.2.11. The characteristics, measured on the built-in microphone, are shown in Fig.2.12. The two lower curves were obtained with different sound pressure levels i.e. with different attenuation of the feedback voltage to the compressor circuit in the Oscillator. The upper curve is the unregulated characteristic.

The second and third harmonics were measured using the arrangement shown in Fig.2.13. Measurements were taken at specific frequencies and the characteristics obtained are shown in Fig.2.14. The harmonics are given re the fundamental, which had a pressure of 120 dB re 2×10^{-5} N/m^2. The sound pressure level at the orifice was kept constant by use of the regulating circuit.

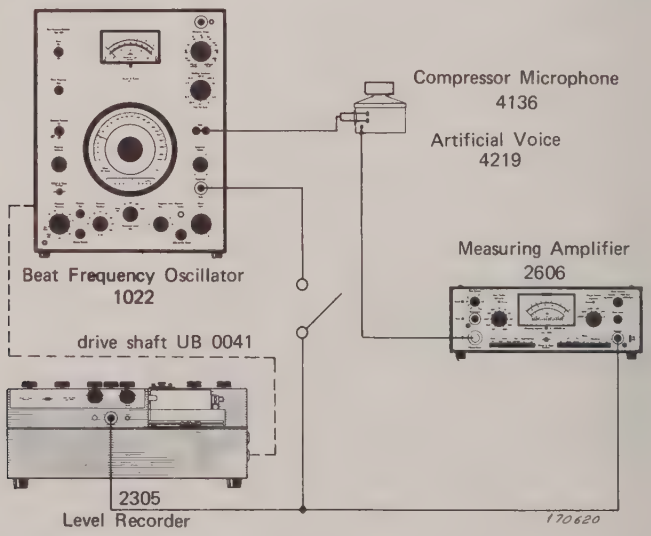

Fig.2.11. Measuring arrangement used for recording the pressure characteristic of the Artificial Voice for a closed mouth opening

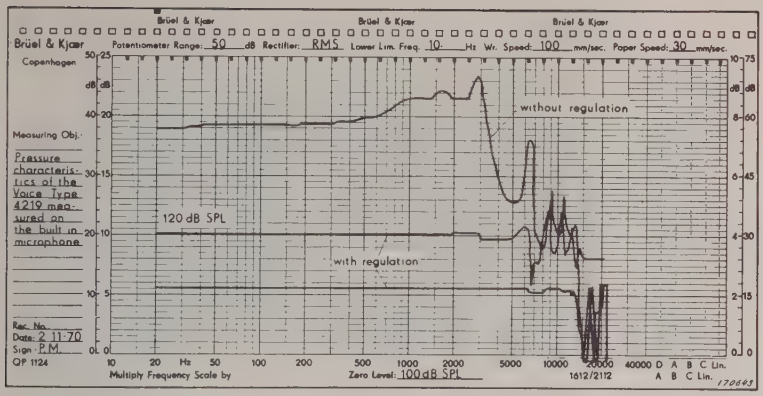
Brüel & Kjær
Potentiometer Range: 50 dB Rectifier: RMS Lower Lim. Freq. 10 Hz Wr. Speed: 100 mm/sec. Paper Speed: 30 mm/sec.
Copenhagen
Measuring Obj.:
Pressure characteristics of the Voice Type 4219 measured on the built in microphone
Rec. No.
Date: 2 11 70
Sign: P.M.
QP 1124
without regulation
120 dB SPL
with regulation
Multiply Frequency Scale by
Zero Level: 100 dB SPL
1612/2112
A B C Lin.

Fig.2.12. Pressure characteristics of the Artificial Voice for a closed mouth opening

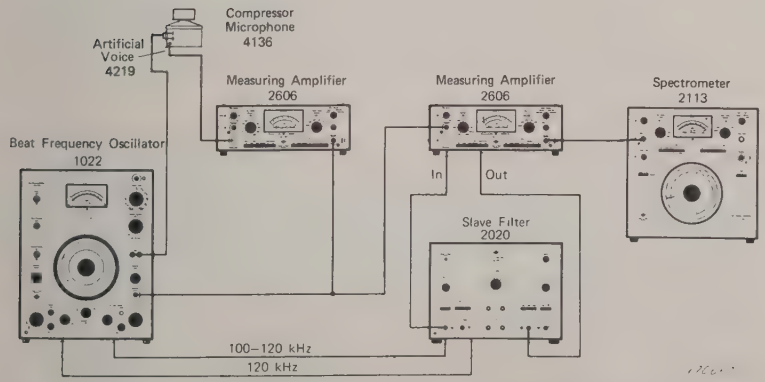

Fig.2.13. Measuring arrangement for recording the frequency characteristics, and the harmonic components produced by the Artificial Voice Type 4219 for a closed mouth opening

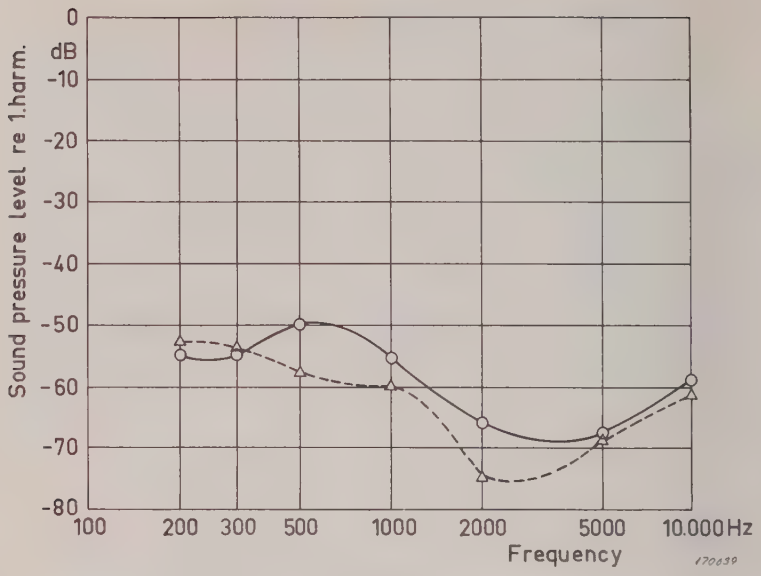

Fig.2.14. 2nd and 3rd harmonics of sound pressure, measured in the mouth orifice for a closed mouth

2.4. DIRECTIVITY

The angular variation of sound pressure was measured using a 1/2 inch Microphone Type 4133 and the set-up shown in Fig.2.15. The microphone was at a distance of 1 meter from the Voice. The Voice was rotated on an axis perpendicular to the symmetry of the Voice axis. The rotation axis was defined by the centre of the mounting plate, see Fig.2.2. The characteristics for different frequencies are shown in Fig.2.16.

2.5. OBSTACLE EFFECT

When an object (e.g. a microphone) is placed in front of the orifice, it gives rise to a change in the acoustic flux from the orifice. If the equivalent circuit of the orifice is considered, see Fig.2.17, the change in flux can be estimated.

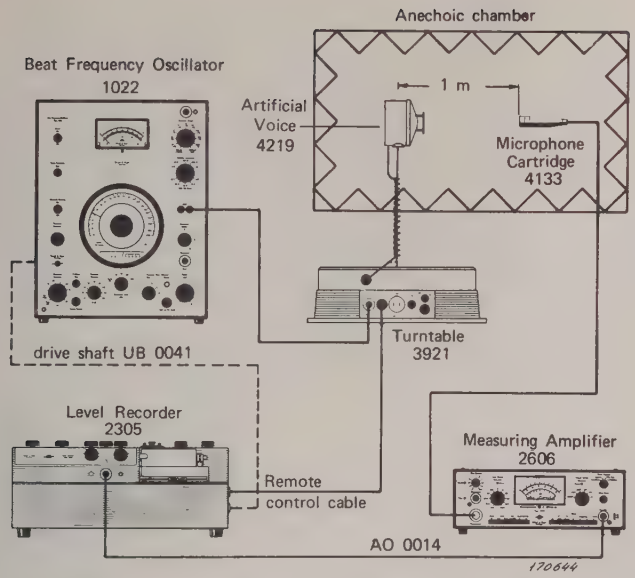

Fig.2.15. Measuring arrangement for recording the angular variation of sound pressure at a distance of 1 meter from the Voice

The generator pressure p_g and the generator impedance Z_g both depend on frequency. The generator pressure p_g is proportional to the voltage across the loudspeaker terminals. The generator impedance Z_g is the acoustic impedance of the voice measured at the compressor microphone. p_c is the pressure on the compressor microphone, Z_L is the acoustic impedance loading the voice. ψ is the flux from the orifice of the voice.

When an obstacle is placed in front of the voice, the acoustic impedance Z_L, loading the voice, changes to a value $Z_L{}^1$. The compressor circuit keeps the pressure p_c at the compressor microphone constant. The compressor circuit compensates for the new load impedance $Z_L{}^1$ by changing the voltage across the loudspeaker terminals. The new generator pressure $p_g{}^1$ is proportional to the new voltage across the loudspeaker terminals.

The original flux ψ is given by:

$$\psi = \frac{p_g}{Z_g + Z_L}$$

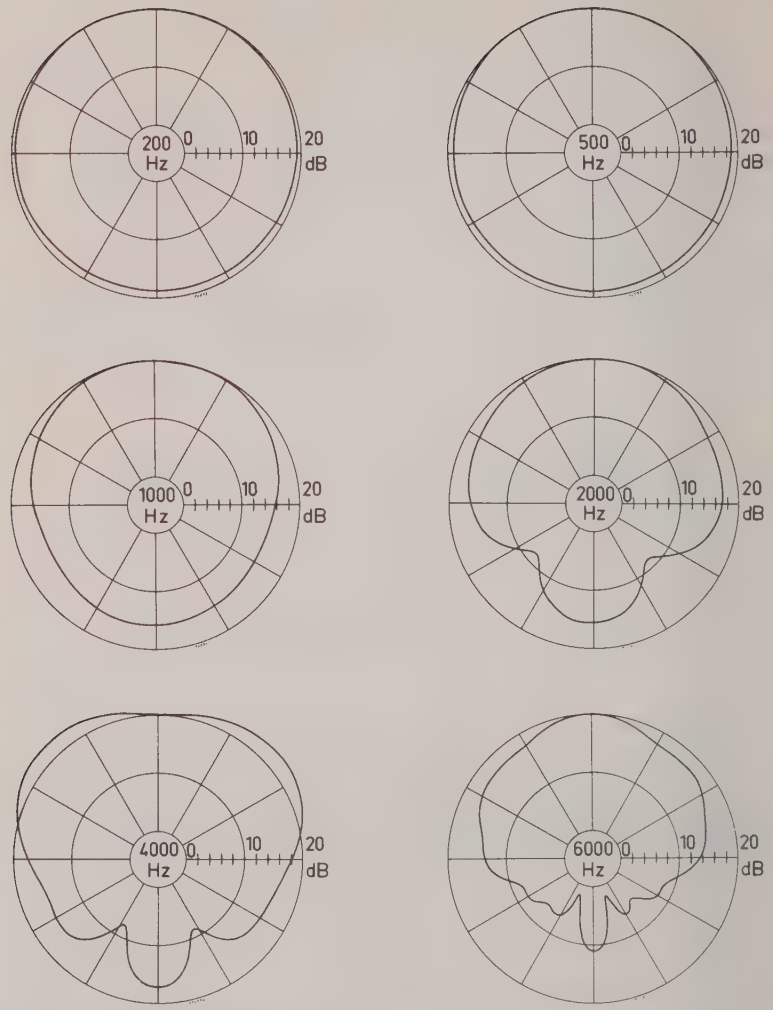

Fig.2.16. Angular variation of sound pressure at a distance of 1 meter from the Voice

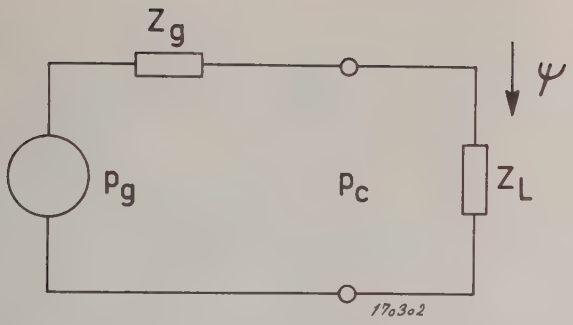

Fig.2.17. Equivalent circuit for the orifice of the Voice Type 4219

The new flux is given by:

$$\psi^1 = \frac{p_g{}^1}{Z_g + Z_L{}^1}$$

Now if $|Z_g| >> |Z_L|$

and $|Z_g| >> |Z_L{}^1|$

then $\frac{\psi^1}{\psi} = \frac{p_g{}^1}{p_g}$

That is, the change in flux equals the change in voltage across the loudspeaker, when both quantities are expressed in dB.

The relation between the load impedance Z_L and the generator impedance Z_g may be estimated by comparison of the unregulated pressure characteristics for the open and closed orifice.

The pressure characteristic for the closed orifice is equivalent to the open circuit voltage of the equivalent circuit. The pressure characteristic for the open orifice is equivalent to the loaded voltage of the equivalent circuit.

The comparison shows that the generator impedance is much higher than the load impedance below 2000 Hz. Above this frequency, the equivalent circuit does not represent the orifice as the generator impedance (Z_g) becomes comparable to the magnitude of the load impedance (Z_L).

The effect of the obstacle can be seen in Fig.2.18. This is the ratio of the voltage applied to the loudspeaker terminals with and without the obstacle

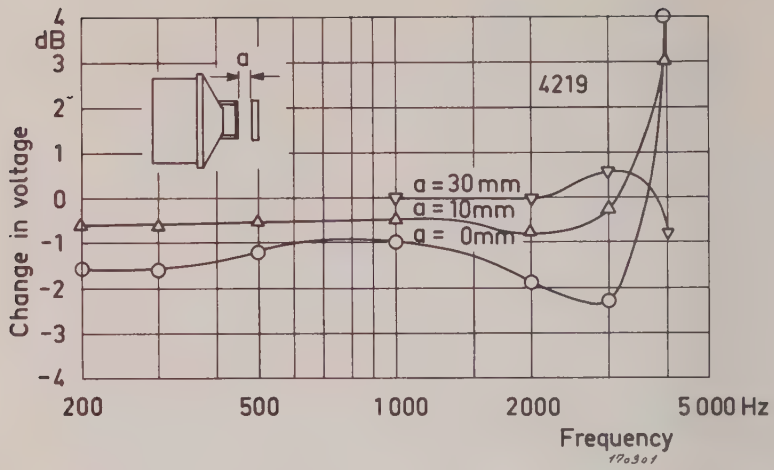

Fig.2.18. Change of voltage across the loudspeaker of the Type 4219 Artificial Voice when an obstacle is presented before the orifice

present, plotted over the frequency range 200 Hz – 5000 Hz. The characteristics are for distances (a) from the lip ring to the obstacle.

Within most of the range used for telephone measurements, the new acoustic flux, caused by the pressure of the obstacle, can be assumed to be proportional to the new voltage applied to the loudspeaker terminals, which keeps the sound pressure level constant at the orifice.

3. OPERATION

3.1. CALIBRATION

When using the Artificial Voice with a measuring amplifier, such as the Type 2606, it is necessary to calibrate the amplifier to compensate for the Artifical Voice preamplifier and cable. The amplifier should be fitted with the appropriate meter scale. This is the scale SA 0061 for the Type 2606 amplifier, when used with the 1/4 inch Microphone Type 4136. The Pistonphone Type 4220, or the Sound Level Calibrator Type 4230, is recommended for this purpose. (**Note:** If the Type 4230 is used it is necessary to fit a 1/4 inch adapter, which is not provided with the calibrator but is separately available under accessory number DB 0310).

Access to the microphone, in order to calibrate the amplifier, can be gained by unscrewing the mouthpiece and removing the microphone and microphone mounting from the spring clip. Full instructions for calibration are found in the Pistonphone and Calibrator manuals, and the Measuring Amplifier Type 2606 manual. After calibration, the microphone and mounting are replaced in the spring clip, and the mouthpiece replaced.

The Voice can now be used as a calibrated sound source.

3.2. RECORDING THE FREQUENCY RESPONSE OF MICROPHONES

The Artificial Voice can be used for measurements under pressure conditions, as well as for free field conditions.

Typical applications for the Artificial Voice used under pressure conditions are the testing of the microphones for oxygen masks, testing of silencers, exhaust pipes, air inlets, etc. In these applications, the orifice of the mouthpiece can be regarded as closed and the pressure characterstics shown in Fig.2.12 apply.

Applications for near field measurements are the testing of hand held professional and semi-professional microphones for tape recorders, intercommunication systems, public address systems, dictating machines, etc. Telephone measurements are also included in this application (see Obstacle Effect page 8).

Applications for far field measurements are the testing of hearing aid microphones, directional microphones, and room acoustics investigations. The acoustical properties of auditoria, theatres etc. can be measured both at the design stage, by using a scale model of the auditorium, or as a final test upon completion of the auditorium. **Note:** The sound pressure level of the Voice may not be sufficient for large auditoria.

To measure the frequency response of a microphone, the Artificial Voice may be used in conjunction with the Beat Frequency Oscillator Type 1022, and a Level Recorder Type 2305. To provide a constant sound pressure level at the orifice of the Voice, a Measuring Amplifier Type 2606 is used to provide a feedback signal to the oscillator. Another Measuring Amplifier Type 2606 is used to amplify the signal from the object under test. The output of this amplifier is then fed to the Level Recorder Type 2305.

The arrangement shown in Fig.3.1 is for the measurement of the frequency response of a microphone. The arrangement can be used for the above applications, and the distance of the microphone from the Voice varied to suit the particular applications.

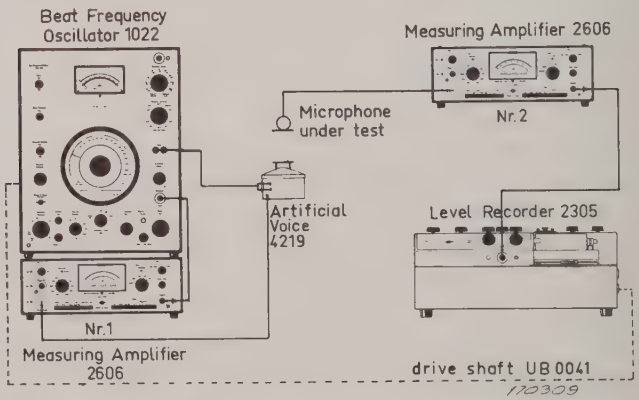

Fig.3.1. Measuring arrangement for recording the frequency response of a microphone

If the arrangement is used for free field measurements the sound pressure at the test object will decrease with distance, according to the curves given in Fig.2.6 and 2.7.

The following procedure can be applied in either the constant sound pressure or the free field cases. Before any measurement is carried out the instruments must be adjusted as follows:

3.2.1. Beat Frequency Oscillator Type 1022

Calibrate the frequency scale as described in the instruction manual for the Oscillator. Then set the control knobs as follows:

OUTPUT LEVEL:	"0"
COMPRESSOR SPEED:	"10 dB/s"
COMPRESSOR INPUT:	Connected to the output of the Microphone Amplifier Type 2606, no. 1.
COMPRESSOR VOLTAGE:	"0"
LOAD:	Connect the terminals to the loud-speaker terminals of the Artificial Voice Type 4219
IMPEDANCE SWITCH:	"6 Ω"
FREQUENCY DIAL:	1000 Hz

The AUTOMATIC SCANNING, MODULATION FREQUENCY, FREQUENCY DEVIATION and the ATTENUATOR control knobs should be set to their "Off" or "Zero" position. (The remaining control knobs should not be moved.)

3.2.2. Level Recorder Type 2305

A 50 dB range potentiometer should be used.

POTENTIOMETER RANGE:	"50 dB"
RECTIFIER RESPONSE:	"RMS"
LOWER LIMITING FREQUENCY:	"20 Hz"

WRITING SPEED:	"100 mm/sec" (large figs.)
POWER:	"On"
MOTOR:	"On"
PAPER DRIVE:	"Start" and "Forward"
PAPER SPEED:	"3 mm/sec" (small figs.)

10: 1 Gear Lever in outer position.

INPUT ATTENUATOR:	"0 dB"
INPUT POTENTIOMETER:	"10"

The DRIVE SHAFT SPEED control should not be touched.

The INPUT terminal should be connected to the RECORDER output of the No. 2 Measuring Amplifier Type 2606.

3.2.3. No. 1 Measuring Amplifier Type 2606

Calibrate the meter to compensate for the microphone and preamplifier section of the Artificial Voice (see Calibration, section 3.1). The set the control knobs as follows:

METER SCALE:	SA 0061
INPUT SWITCH:	"Preamplifier"
INPUT SECTION ATTENUATOR:	To a suitably high setting
OUTPUT SECTION ATTENUATOR:	"x1"
GAIN CONTROL:	"Cal"
METER FUNCTION:	"RMS fast"
OUTPUT SELECTOR:	"A.C."

The built-in microphone of the Artificial Voice should be connected to the PREAMP input.

Do not select any Weighting Networks.

3.2.4. No. 2 Measuring Amplifier Type 2606

The amplifier must be calibrated for voltage measurements (see Type 2606 Instruction Manual). Then set the control knobs as follows:

METER SCALE:	SA 0037
INPUT SWITCH:	"Direct"
INPUT SECTION ATTENUATOR:	"1 V"
OUTPUT SECTION ATTENUATOR:	"x1"
METER FUNCTION:	"RMS fast"
GAIN CONTROL:	"Cal"
OUTPUT SELECTOR:	"A.C."

Do not select any Weighting Networks.

3.2.5. Recording Frequency Response Characteristics

When the instruments are adjusted as above the frequency response can be measured.

1. Place the microphone to be tested in front of the Voice mouthpiece.

   a) When pressure conditions are required the lip ring of the mouthpiece must be removed, and the microphone should be an airtight fit with the mouthpiece, possibly mounted by means of a piece of foam rubber.

   b) When free field conditions are required the Voice and the micro-

phone to be tested should be placed in an anechoic chamber. The distance of the microphone from the Voice can be measured using the lip ring as a reference plane.

2. Connect the output lead from the microphone under test to the appropriate input of the No. 2 Measuring Amplifier Type 2606.

3. Slowly turn the OUTPUT LEVEL knob of the Oscillator to maximum. Check that the compressor circuit is operating correctly – if so, the output signal level will first increase and then be regulated to a value below full scale meter deflection.

4. Select a frequency of 1 kHz.

5. Adjust the COMPRESSOR VOLTAGE knob of the Oscillator until the meter pointer of the No. 1 Measuring Amplifier Type 2606 indicates a suitable sound pressure level in the mouth orifice of the Voice. When very low sound pressure levels are desired the loudspeaker should be connected to the ATTENUATOR OUTPUT of the B. F. O. in order to make the compressor circuit work in the middle of its working range, see also the Instruction Manual for Type 1022.

6. Adjust the SECTION ATTENUATORS on the No. 2 Amplifier Type 2606 until a suitable deflection is obtained on the Level Recorder Type 2305.

7. Slowly scan the frequency range to make sure that the stylus deflection of the Level Recorder is well within the width of the recording paper for all frequencies. Otherwise readjust the amplification of the No. 2 Measuring Amplifier or adjust the INPUT POTENTIOMETER and INPUT ATTENUATOR knobs on the Level Recorder.

8. Set the frequency of the Oscillator to 20 Hz.

9. Switch the AUTOMATIC SCANNING of the Oscillator to "ON".

10. Adjust the recording paper until the writing arm indicates 20 Hz by turning the grooved finger wheel (any backlash in the mechanical system can be eliminated by approaching the required frequency from a higher frequency).

11. Start the Level Recorder by means of the SINGLE CHART press button. The button must remain depressed for a definite minimum period of time. This period is approximately the time it takes for the paper to travel 4 cm. Then an internal cam operates and takes over from manual control. The frequency range is now automatically scanned, and the frequency response curve of the microphone under test is recorded at a constant sound pressure level.

4. SPECIFICATIONS

Frequency Range:	50 Hz to 10 kHz ±1 dB (with regulation and 100 dB SPL at mouth opening).
Max. Sound Pressure Level:	115 dB for free field measurements at the front of the lip ring. 140 dB for measurements under constant sound pressure conditions. (Obtained when connected to Beat Frequency Oscillator Type 1022. 6 ohm output).
Distortion:	Less than 1% at 1 kHz at sound pressure levels lower than 115 dB (measured with the built-in microphone).
Mouth Opening:	Diameter 20 mm.
Lip Ring:	Positioned 10 mm from mouth opening. Outer diameter 48 mm.
Loudspeaker:	Power handling capacity 3 W. Impedance 8 Ω. Diameter 90 mm (3.5 inch).
Preamplifier:	Supply Voltage: 120 V. Polarization Voltage: 200 V. Frequency range with 6 pF*) at input: 20 Hz to 20 kHz ±0.5 dB. Max. Output Voltage: 30 V. Noise Voltage with 6 pF*) at input: $<100\ \mu$V. 20 Hz to 20 kHz. Input Capacitance: <1 pF. Attenuation: 0.1 dB. Attenuation with 6 pF*) at input: 1 dB.
Dimensions:	Height: 9 cm (3.5 in). Diameter: 10 cm (4.0 in). Weight: 1.25 kg (2.8 lb).
Accessories Included:	1/4 inch Condenser Microphone Type 4136, (preamplifier and cable is built into 4219).

*) 6 pF corresponds to the capacitance of the 1/4 inch Condenser Microphone Type 4136.

B & K INSTRUMENTS:

ACOUSTICAL....
Condenser Microphones
Piezo-Electric Microphones
Microphone Preamplifiers
Microphone Calibration Equip.
Sound Level Meters
(general purpose-precision- and impulse)
Standing Wave Apparatus
Tapping Machines
Noise Limit Indicators

ELECTROACOUSTICAL....
Artificial Ears
Artificial Mouths
Artificial Mastoids
Hearing Aid Test Boxes
Telephone Measuring Equipment
Audiometer Calibrators
Audio Reproduction Test Equip.

STRAIN....
Strain Gauge Apparatus
Multipoint Panels
Automatic Selectors
Balancing Units

VIBRATION....
Accelerometers
Accelerometer Preamplifiers
Accelerometer Calibrators
Vibration Meters
Magnetic Transducers
Capacitive Transducers
Vibration Exciter Controls
Vibration Programmers
Vibration Signal Selectors
Mini-Shakers
Complex Modulus Apparatus
Stroboscopes

GENERATING....
Beat Frequency Oscillators
Random Noise Generators
Sine-Random Generators

MEASURING....
Measuring Amplifiers
Voltmeters
Deviation Bridges
Megohmmeters

ANALYZING....
Band-Pass Filter Sets
Frequency Spectrometers
Frequency Analyzers
Real-Time Analyzers
Slave Filters
Psophometer Filters
Statistical Analyzers

RECORDING....
Level Recorders
(strip-chart and polar)
Frequency Response Tracers
Tape Recorders

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